LOOKING BACK: STUDENTS' PERCEPTIONS OF THE RELATIVE ENJOYMENT OF PRIMARY AND SECONDARY SCHOOL SCIENCE

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ABSTRACT

This paper reports and discusses a contentious result from an Australia-wide study of the influences on students' decisions about taking senior science subjects. As part of the *Choosing Science* study (Lyons and Quinn 2010) 3759 Year 10 students were asked to indicate which stage of their schooling (lower primary, upper primary, lower secondary, middle secondary) they had most enjoyed learning science. Around 78% of students indicated that they had enjoyed learning science more in secondary than in primary school, and 55% enjoyed it the most during Years 9 and 10. The perception that school science was more enjoyable in high school was also found among students who did not intend taking science in Year 11, though to a lesser extent. These findings are unexpected and significant, challenging the prevailing view that enjoyment of school science steadily declines after primary school. The paper elaborates on the findings and suggests that the different conclusions arrived at by studies in this field may be due to the different methodologies employed.

Keywords: *attitudes to science, enjoyment of science, experiences of primary and secondary school science,*

INTRODUCTION

This paper presents a single result from a large-scale national study which investigated the influences on Year 10 (15-16 year old) students' decisions about taking science subjects in Year 11. The *Choosing Science* study sought the opinions of Year 10 students (n=3759) on a broad range of issues in order to construct a detailed picture of the deliberation processes and influences involved in these decisions. While the study generated numerous results, we focus in this paper on a potentially contentious finding in the hope that the constructive feedback the paper may generate will contribute to a resolution about its interpretation. The finding concerns the students' opinions as to which stage of their schooling they had most enjoyed learning science. Based on established evidence within the literature, our expectation was that students would identify their upper primary school experiences as having been the most enjoyable, followed by a decline in the level of enjoyment once they progressed to junior and middle secondary school. Contrary to these expectations, students overwhelmingly regarded their secondary school experiences to have been the most enjoyable, with more than half indicating that

their most recent experiences (Years 9 and 10) had been the best. This finding is contrary to an extensive body of Australian and international research, and therefore of substantial interest.

This paper presents and discusses the literature concerning students' enjoyment of and attitudes towards school science. It then briefly describes the *Choosing Science* study and details the relevant finding. The paper then discusses possible interpretations and implications of the finding for future policy and research.

LITERATURE REVIEW

A substantial body of Australian and international literature argues that children's attitudes to school science decline once they leave primary school, and tend to remain lower throughout the junior high school years. Indeed, the evidence for this view is overwhelming and has been catalogued in many influential reports in Australia (e.g. Goodrum Hackling & Rennie, 2001; Tytler, 2007) and overseas (e.g. Murphy & Whitelegg, 2006; OECD, 2006; Osborne & Dillon, 2008). So prevalent is this view that it is considered an orthodoxy in many policy domains concerning science education (see for example, http://www.parliament.uk/documents/post/pn202.pdf).

The Australian research evidence most often cited in support of this view includes Speering and Rennie (1996) and a succession of TIMSS reports (Lokan, Ford & Greenwood, 1996, 1997; Thomson & Fleming, 2004). A number of earlier studies (e.g. Rosier & Banks, 1990; Baird, Gunstone, Penna, Fensham & White, 1990) also concluded that students' attitudes become more negative over the primary/secondary transition. Speering and Rennie's longitudinal study explored the responses and attitudes to school science of students from three West Australian schools during their transition from the final year of primary school (Year 7) to the first year of secondary school (Year 8). The authors reported a noticeable decrease in the enjoyment of science from Year 7 to Year 8 for both boys and girls. The authors consider one of the chief reasons for this decline to be the less positive teacher-student relationships experienced in their secondary school science classrooms.

Research evidence on a national scale is provided by the Trends in International Mathematics and Science Studies (TIMSS). Thomson and Fleming (2004) reported that 63% of Year 4 students participating in TIMSS 2002 "agreed at lot" that they enjoyed learning science. Among Year 8 students in the same study, only 29% "agreed a lot". A similar contrast between the views of primary and secondary students was reported in earlier TIMSS studies (Lokan, Ford & Greenwood, 1996, 1997), supporting the contention that science education in the junior secondary years impacts negatively on students' interest and engagement.

Similar results have been found among other TIMSS countries. For instance, the 2007 TIMSS International Report (Martin, Mullis, & Foy, 2008) found far lower proportions of 8th Grade students in the high 'Positive Affect Towards Science (PATS)" category than was the case among 4th Grade students in many countries, including Japan, Italy, Norway, England and the US. The PATS index included responses to questions about whether students enjoy learning science, like science more generally, or think it is boring. Consistent with the TIMSS results, a recent study by Bennett and Hogarth (2009) confirmed earlier UK research (e.g. Osborne, Simon & Collins, 2003; Schoon, Ross & Martin, 2007) that positive attitudes to school science decline significantly between the ages of 11 and 14 years. Research in the US (e.g. George, 2000; Neathery, 1997; Simpson & Oliver, 1990) and Sweden (Lindahl, 2003) reached similar conclusions.

Despite the weight of evidence, results from a small number of studies challenge the prevailing view. In an Australia study reminiscent of that conducted by Speering and Rennie (1996), Logan and Skamp (2007) found that Year 6 students generally retained their levels of interest in science after a year in secondary school. Based on results from

a similar qualitative study in the UK, Campbell (1999) reported that upon moving to secondary school, pupils actually tended to reflect less positively on their primary school experiences. A larger, mainly quantitative study recently undertaken for the Wellcome Trust (Butt, Clery, Abeywardana, & Philips, 2009) found that a large majority of 14 to 18 year olds (84%) considered science more interesting at secondary school than primary school. The most common reasons provided by the students were that they studied more interesting topics at secondary school and there were more chances to do experiments.

Counter examples such as those above are few and far between compared to the bulk of research upon which the prevailing view is founded. Nevertheless, a number of studies also argue that declines in enjoyment of school science should be considered in the context of declines in students' attitudes to school more generally. The literature supporting this view is quite substantial and broadly based (see Wigfield & Cambria, 2010 for a review). For example, a large scale German study (Baumert, 1995) found that interest in all school subjects declines as young people become more involved in developing a social identity. In Australia, declines in attitudes towards school were identified by Ainley (1995) and Rosier and Banks (1990) and were acknowledged by Speering and Rennie (1996) as a possible influence on their results.

This literature review provides a context for appreciating the significance of the *Choosing Science* findings reported in this paper. While necessarily brief, the review has conveyed something of the depth and influence of research supporting the view that students' attitudes to and enjoyment of school science decline between upper primary school and middle secondary school. While there are counter examples in the literature, these tend to have less impact on prevailing views, particularly with regard to education policy.

RESEARCH DESIGN

Choosing Science was designed to investigate the influences on Year 10 students' decisions about taking Year 11 science subjects. The study proceeded in two phases. In Phase One, 589 secondary school science teachers were surveyed to identify their perceptions about the enrolment declines and students' deliberation processes. While Phase One is not discussed here, findings from this survey informed Phase Two, a survey of 3759 Year 10 students who had recently chosen their subjects for Year 11. This design allowed exploration of the perceptions among both teachers and students, and enabled comparisons to be drawn between them.

Instrument

This paper concerns students' responses to a single question: 'In which stage of your schooling did you most enjoy learning science?' Students responded to the question by nominating one of the following stages: Lower primary, Upper Primary, Lower secondary, or Middle secondary (Yrs 9 & 10). Three of these stages were deliberately expressed in broad terms (i.e. without explicit Year designations) to allow for the different state and territory transition structures. In ACT, NSW, Tasmania and Victoria, Year 6 is the final year of primary school, whereas in Queensland, South Australia and Western Australian Year 7 is the final year of primary school. In the Northern Territory, both systems were in operation at the time the study cohort entered high school. The 'Middle secondary' category was explicitly identified as Years 9 and 10 to avoid confusion, as these years are standard across Australia.

Sample

The Phase Two sample consisted of Year 10 students who intended to continue to senior secondary school and who had recently chosen their subjects for Year 11. The students were from schools across Australia nominated by science teachers participating in Phase One. Initially, 243 schools were nominated, from which a proportionally representative sample of 200 was selected based on state/territory, sector and geographical representation. Permission was then sought from education authorities, principals, parents and students.

A total of 3801 students completed the online survey in December 2007. Of these, 3759 responses were deemed suitable for analysis, representing about 1.4% of the Australian Year 10 cohort (Australian Bureau of Statistics [ABS], 2008). All states and territories were well represented, with the largest contingents being from NSW, Queensland, Victoria and South Australia. Close to half the students attended capital city schools, while about 35% were from rural or remote areas. Approximately 42% were from Government schools, with Independent and Catholic systemic schools contributing about 37% and 21% of the sample respectively. Further details of the sample composition can be found in the full report (Lyons & Quinn, 2010).

Analysis

Responses were summarised using SPSS frequency tables and crosstabulated against categorical variables including sex, state/territory, school sector, location and science enrolment decision. Patterns of difference across these variables were analysed using chi-square contingency table tests. A significance level of $p<.001$ was adopted throughout. Where relevant, Cramer's V was used as a measure of effect size. Cramer's V statistics were interpreted as indicating small, medium or large effect sizes in accordance with Cohen's (1988) criteria. Where meaningful significant differences were found, adjusted standardised residuals (ASRs) were used to evaluate the sources of the differences detected by significant chi-square relationships. ASRs greater than +3.30 or less than –3.30 indicate (at 99.9% probability level) that individual cell counts are significantly different to those expected if no association existed between the variables, with those greater than +2.58 or less than - 2.58 suggestive of significant differences (at a probability level between 99 and 99.9%). The magnitude of the ASR (in either + or - direction) reflects the size of the difference between observed and expected counts.

RESULTS

Students' overall responses are summarised in Figure 1. Around 78% of students reported enjoying science most in secondary school, with more than 55% claiming they enjoyed it most in middle secondary (Yrs 9 & 10).

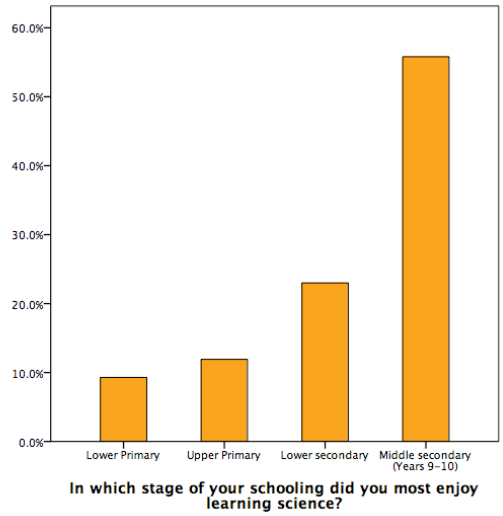

Figure 1: Responses to the question "In which stage of your schooling did you most enjoy learning science?" (N=3759)

Crosstabulations with independent variables revealed no significant differences in the responses of girls and boys or students in different school sectors. While significant differences were found across the four geographical location categories (capital city,

large non-capital city pop. >25000, rural city pop. 25000-10000, rural or remote town pop. <10000) effect size calculations indicated the differences were not meaningful.

The responses of students deciding to take no science subjects in Year 11 (N=908) were compared against those of students choosing one or more science subjects (N=2567). The results, shown in Figure 2, indicate that non-science students were more inclined than those choosing science to consider their primary school science experiences as the most enjoyable. The differences were significant and meaningful ($\chi^2(3)= 250.759$; $p<.001$; Cramer's V = .269). Nevertheless, it is clear from the figure that even students deciding not to take any senior science tended to consider their secondary school science experiences as having been the most enjoyable. In all, 65% of non-science students reported that they had enjoyed secondary science more than primary science.

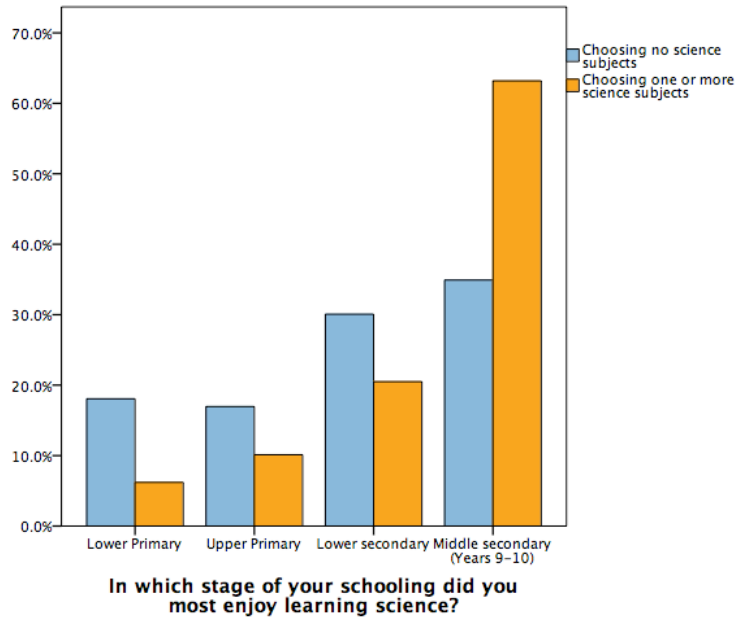

Figure 2: Responses to the question "In which stage of your schooling did you most enjoy learning science?", by science and non-science students (N=3475)

This result was interrogated further by examining the responses of students choosing different science subjects. This analysis was problematic due to the range of subject combinations students can choose. To simplify this, respondents were allocated to separate choice categories based on the subjects in which they had enrolled. These categories are summarised in Table 1.

Crosstabulations of students' responses across choice categories revealed significant differences with medium effect size ($\chi^2(12)= 348.118$; $p<.001$; Cramer's V = .183). Consistent with the preceding discussion, Figure 3 shows that those choosing no science were more inclined than those in other choice categories to believe their science experiences in primary school were the most enjoyable. The figure also shows that students in the Phys+ and Chem+ categories were far more inclined than those in other categories to nominate their most recent school science experiences as having been the most enjoyable. Conversely, these students were the least inclined to nominate their primary school experiences as having been the most enjoyable.

Table 1: Choice categories, possible subject combinations and student numbers

Choice category	Possible subject combinations	Category counts	
Phys+	physics only physics plus one or more additional science subject(s)	Girls	349
		Boys	658
		Total	**1007**
Chem+	chemistry only chemistry plus biology and/or other science subject(s)	Girls	362
		Boys	241
		Total	**603**
Bio+	biology only biology plus other science subject(s)	Girls	461
		Boys	207
		Total	**668**
Othersci	other science subject(s) only (e.g. Human Biology, Earth and Environmental Science, Geology, Senior Science)	Girls	177
		Boys	112
		Total	**289**
Nosci	No science subjects	Girls	508
		Boys	400
		Total	**908**

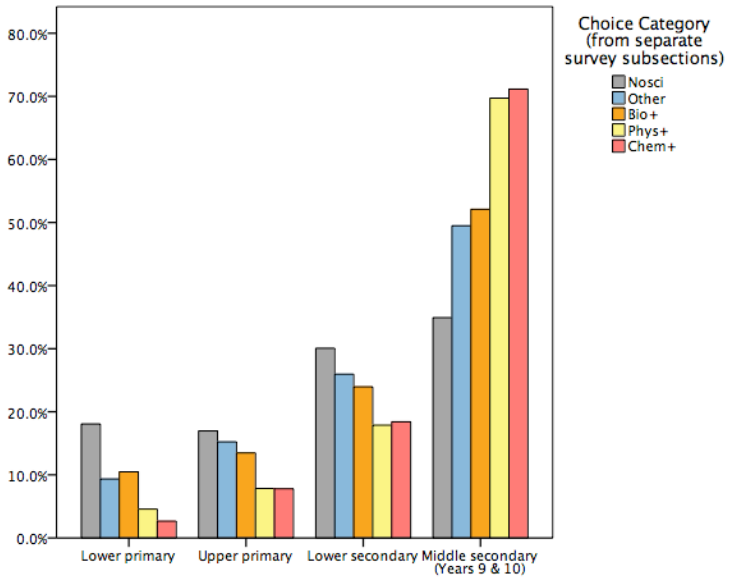

Figure 3: Responses to the question "In which stage of your schooling did you most enjoy learning science?", by students in different science choice categories (N=3475)

This result suggests a strong association between perceived enjoyment of science in the middle secondary years and intention to participate in senior physics and chemistry. In considering the implications of this result it should however be noted that students in the Phys+ and Chem+ categories were more likely than others to have chosen two or more science subjects, so category choice may also be a *de facto* indicator of the amount of science taken.

DISCUSSION

These results represent something of a conundrum when compared to prevailing thought about the pattern of student enjoyment of school science throughout primary and secondary school. As detailed earlier, current understanding of this pattern has been informed by substantial evidence that primary school students tend to rate their enjoyment of school science higher than do students in secondary school. In this regard the TIMSS results are particularly convincing due to the size and design of the samples. Nevertheless, there is some support for our findings. The research conducted by Butt et al. (2009) in the UK generated very similar results, with around 84% of their sample of 374 adolescents (age 14-18 years) agreeing that their interest in learning science was greater in secondary school than in primary school.

Following discussion of the results with colleagues, further reading and reflection we contend that the most likely explanation for this difference lies in the research methodologies adopted by different studies. The key studies discussed earlier all employed either a longitudinal or cross-sectional approach. That is, the researchers either collected data from the same students at different times (primary and secondary years) (e.g. George, 2000; Lindahl, 2003; Speering & Rennie, 1996), from separate age cohorts (primary and secondary) at the same time (e.g. Bennett & Hogarth, 2009; the TIMSS studies) or employed both strategies (Simpson & Oliver, 1990).

In contrast, our study and that conducted by Butt et al. (2009) were retrospective in nature, in that students were asked to reflect back on their memories of primary and secondary science classes and assess which had been the most enjoyable. None of the studies discussed earlier took this approach, and it has been difficult to identify others that have done so. If other retrospective studies can be found which challenge the conclusions drawn from longitudinal and cross sectional studies it will raise two very important questions:

- Do the conclusions from attitudinal research depend on *when* students are asked about their experiences?

- If so, which data collection strategy – retrospective or longitudinal/cross-sectional - has the greatest validity and reliability with respect to conclusions about the influence on decisions about further participation in science?

Certainly the retrospective approach is open to criticism about the reliability of students' perceptions about earlier experiences and attitudes. It is salient, for example, to question the accuracy of Year 10 students' memories of science in lower primary classes. In addition, it has been suggested that during their primary years students may not even have recognised some of their class activities as "science lessons" (Helldén, pers comm. Dec. 2009).

Likewise, a number of questions can also be asked of conclusions drawn from longitudinal and cross-sectional studies of attitudes to school science. First, it is reasonable to ask to what extent these studies took into account the evidence that students' enjoyment of school in general declines during the early secondary years (e.g. Hendley, Stables and Stables, 1996; Osborne et al., 2003; Wigfield & Eccles, 1992). Speering and Rennie (1996) recognised this complication, acknowledging that it is very difficult to isolate attitudes to school science from broader attitudes in such research.

Second, given the significant psychological and sociological development students undergo during early adolescence, and the attendant changes in their perspectives, a broader question might be whether it is valid to assume that reported changes in attitude reflect the object (in this case, school science) rather than the subject. As Wigfield and Eccles (1992) note, students' worlds expand rapidly during adolescence, their views, priorities and frames of reference shift and evolve. Clearly any changes in students'

perceptions of “school science” at age 10 and at age 15 are likely to reflect subjective changes as well as any changes in the objective characteristics of “school science. Third, complicating this further is the greater range of subjects students experience in high school. Attitudes are relative, after all, and broader experiences may affect students’ judgements of what constitutes an enjoyable subject, just a driving a wider range of cars may affect one’s assessment of the car one drives on a daily basis.

Fourth, we must also consider whether students of different ages respond to survey instruments in the same way. Bennett and Hogarth (2009) for example uncovered a tendency for high school students to favour more ambivalent responses to survey items than did younger students.

Finally, the question raised by Helldén (pers. comm.) about whether in retrospect students recognise what they did in primary science lessons as being science, applies just as well to longitudinal and cross-sectional studies. Are primary science and secondary science similar enough that comparisons of attitude are valid? In Australia, primary science lessons are often infrequent enough to be a novelty, typically activity based, conceptually uncomplicated and (arguably) fun. By comparison, science in Year 8 and 9 is more rigorous, conceptually difficult and has a greater focus on exams. Is it really so surprising that longitudinal or cross-sectional studies reveal that students enjoy it less? On the other hand, the rewards of secondary science learning tend to be longer term and cerebral: intellectual stimulation, the satisfaction associated with understanding concepts and patterns, the construction of schema that hopefully “make sense” of the world. The value of such things can often only be appreciated in retrospect.

CONCLUSION

For many reasons it is important that attention is directed to the validity of research strategies targeting the affective elements of students’ learning experiences, in order to most accurately capture students ‘real’ attitudes. In the context of students’ deliberations about enrolling in Year 11 science subjects, it is also pertinent to ask: Which perceptions of science are students most likely to rely on when making this decision? Will they call on the views they held when they were in primary school, or those they hold at the end of Year 10? It is arguably the latter. A student’s perceptions of the history of his or her attitudes to school science, regardless of its accuracy, is more relevant to the decision than the actual history itself.

There are also implications for education policy tied up in these questions. Many policy decisions are predicated on the understanding that there is something wrong with junior secondary science, and indeed this may well be the case. Yet the results of the *Choosing Science* and Wellcome Trust (Butt et al. 2009) studies paint an alternative picture in which students’ enjoyment of school science increases as they progress through high school. It is apparent that this contradiction needs to be resolved in order to clarify questions about targeting curriculum reform and school resourcing. Clearly the first step is to conduct a close examination of the studies included here, followed if necessary by empirical research designed expressly to address the questions raised in this paper.

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